

OCT 23 1950

NBS CIRCULAR *494*

# **Plastics Research and Technology at the National Bureau of Standards**

---

**UNITED STATES DEPARTMENT OF COMMERCE**

**NATIONAL BUREAU OF STANDARDS**

## PERIODICALS OF THE NATIONAL BUREAU OF STANDARDS

As the principal agency of the Federal Government for fundamental research in physics, chemistry, mathematics, and engineering, the National Bureau of Standards conducts projects in fifteen fields: electricity, optics, metrology, heat and power, atomic and radiation physics, chemistry, mechanics, organic and fibrous materials, metallurgy, mineral products, building technology, applied mathematics, commodity standards, electronics, and radio propagation. The Bureau has custody of the national standards of measurement and conducts research leading to the improvement of scientific and engineering standards and of techniques and methods of measurement. Testing methods and instruments are developed, physical constants and properties of materials are determined, and technical processes are investigated.

### Journal of Research

Internationally known as a leading scientific periodical, the Journal presents research papers by authorities in the specialized fields of physics, mathematics, chemistry, and engineering. Complete details of the work are presented, including laboratory data, experimental procedures, and theoretical and mathematical analyses. Each of the monthly issues averages about 100 two-column pages; illustrated. Annual subscription: domestic, \$4.50; foreign, \$5.50.

### Technical News Bulletin

Summaries of current research at the National Bureau of Standards are published each month in the Technical News Bulletin. The articles are brief, with emphasis on the results of research, chosen on the basis of their scientific or technologic importance. Lists of all Bureau publications during the preceding month are given, including Research Papers, Handbooks, Applied Mathematics Series, Building Materials and Structures Reports, and Circulars. Each issue contains 12 or more two-column pages; illustrated. Annual subscription: domestic, \$1.00; foreign \$1.35.

### Basic Radio Propagation Predictions

The Predictions provide the information necessary for calculating the best frequencies for communication between any two points in the world at any time during the given month. The data are important to all users of long-range radio communications and navigation, including broadcasting, air line, steamship, and wireless services, as well as to investigators of radio propagation and ionosphere. Each issue, covering a period of one month, is released three months in advance and contains 16 large pages, including pertinent charts, drawings, and tables. Annual subscription: domestic, \$1.00; foreign, \$1.25.

Order all publications from the Superintendent of Documents,  
U. S. Government Printing Office, Washington 25, D. C.

UNITED STATES DEPARTMENT OF COMMERCE • Charles Sawyer, *Secretary*  
NATIONAL BUREAU OF STANDARDS • E. U. Condon, *Director*

# Plastics Research and Technology at the National Bureau of Standards

A Review and Bibliography

*By* Gordon M. Kline



National Bureau of Standards Circular 494

Issued June 15, 1950

## Contents

	Page
I. Introduction-----	1
II. Plastics research and technology-----	2
1. Properties of plastics-----	2
2. Testing of plastics-----	4
3. Chemistry of plastics-----	5
4. Plastic materials-----	5
5. Applications of plastics-----	5
6. Specifications for plastics-----	8
7. General information on plastics-----	8
8. Investigation of German technology-----	9
III. Bibliography-----	9

# Plastics Research and Technology at the National Bureau of Standards

## A Review and Bibliography

By Gordon M. Kline

This paper consists of a summary of the activities of the National Bureau of Standards relating to plastics. It gives a brief outline of the work carried on in each of eight different fields of investigation and concludes with 160 references to publications by members of the staff of this Bureau.

### I. Introduction

Work in plastics at the National Bureau of Standards began in 1917, less than a decade after the discovery of the first synthetic resin by Dr. Baekeland. Phenolic insulating materials were being used by the Government for radio apparatus in World War I. Practically no measurements had been made of the properties of these materials at radio frequencies. The Bureau was requested to obtain such data, and the project soon broadened into a general research on the properties of the phenolic laminates, the results of which were published in 1922.

The next phase of the Bureau's activity in this field began in 1929. The Army Quartermaster Corps asked that an investigation be undertaken to determine how the domestically available synthetic resins could be used to replace leather, rubber, shellac, tung oil, and other strategic materials in essential military equipment. From this time on there has been a continuing program of research on plastics at this Bureau. Their growth in importance as a new material of commerce was recognized in October 1935 by the formation of the Organic Plastics Section.

A notable portion of the work of the section has been concerned with the use of plastics on aircraft. These two industries practically grew up together, and the lightweight products of the one were of distinct interest and advantage to the other. It was quite logical that the Bureau would be called upon to provide much of the basic data needed for proper selection and use of the synthetic materials for aeronautical applications. The Plastics Section is at present working on research projects sponsored by the Department of the Air Force,

Navy Bureau of Aeronautics, and National Advisory Committee for Aeronautics.

The nature of the Bureau's activities on plastics changed markedly when we entered World War II. It became a proving ground for plastics in all types of military equipment. The facilities of the section were utilized in the development and testing of plastic products by the various war agencies, including the War and Navy Departments, the Maritime Commission, Office of Civilian Defense, and the War Production Board. Many of the items made of plastics became standard stores in the various branches of the service. Typical of the diversified applications of plastic materials that were submitted for testing during the war years are the following: aircraft light covers, baking-type resinous coatings for protection of steel hardware, bayonet handles, binocular coverings and housings, buttons, canteens, card holders, clock housings, combs, compass dials, dopes for airplane fabric, foot tubs, fuze parts, goggles, insignia, helmet liners, insect screening, shaving brushes, tableware, transparent plastics for aircraft enclosures, and whistles.

With the end of the war, emphasis has been shifted to the determination of fundamental properties and constants and the development of methods of test and specifications for plastic products. At the present time about 30 professional and sub-professional employees at this Bureau spend their full time in this research program on plastics. The work is financed in part by direct congressional appropriation and in part by transfer of funds from other Government agencies.

International contacts were established in 1942 when the Chief of the Organic Plastics Section spent a month in Great Britain at the request of the British Ministry of Supply and British Ministry of Aircraft Production. The wartime activities of the two countries in the plastics field were reviewed and coordinated in a series of conferences and visits to British production centers. This exchange of information was furthered in 1943-44 by the visits to this country of N. J. L. Megson, Chief of the Plastics and Rubber Advisory Service, British Ministry of Supply, and C. D. Philippe,

Plastics Engineer, British Ministry of Aircraft Production.

Developments in plastics in Germany during the period of World War II were investigated in April, May, and June 1945, by the Chief of the Organic Plastics Section who was detailed to the Army Ordnance Department for this purpose. A wealth of previously unpublished information on German production methods and research activities was accumulated in the course of this 3-month survey and has been made available in a series of reports

## II. Plastics Research and Technology

The experimental work of the Organic Plastics Section falls generally into three categories. The first of these relates to evaluation of plastic materials and products for other Government agencies; the results of these tests are generally of limited interest and are submitted in the form of reports to the specific organization concerned. The second category pertains to the preparation of specifications; the data accumulated in the course of this work provide the basis for the selection of the test methods and requirements incorporated into the published specifications. The third and largest category consists of systematic studies of the properties and physical constants of plastics. In many instances the materials and properties selected for investigation relate to some particular field of application such as aircraft, adhesives, dentures, shoe soles, and the like. The results of these studies are usually reported in the form of printed publications.

Over the years the research investigations and advisory services on plastics at the National Bureau of Standards have led to the publication of over 160 papers by members of its staff. The various subjects covered in this work are listed in this section, accompanied by a brief description of what has been accomplished in each separate phase. References are cited, by numbers in parentheses, to the original publications, classified under the same headings in section III.

### 1. Properties of Plastics

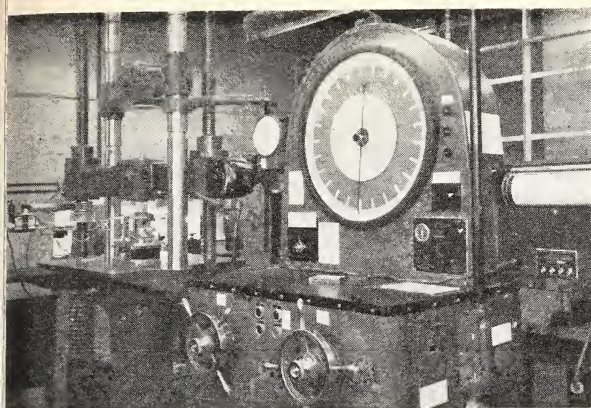
A major phase of the experimental program of the Organic Plastics Section since its formation in 1935 has been the determination of the properties of plastics. This Bureau has always been a recognized center for such work because of its exceptional testing facilities and personnel trained in making precise measurements. The new plastics industry, therefore, like the older rubber, textile, paper, and leather industries, has cooperated with this Bureau from the start to obtain a better knowledge of the performance characteristics of its prod-

ucts. Some of these investigations have been concerned with the evaluation of plastics for particular applications; these will be discussed in another section. Others have been concentrated on special properties; these will be discussed in this section.

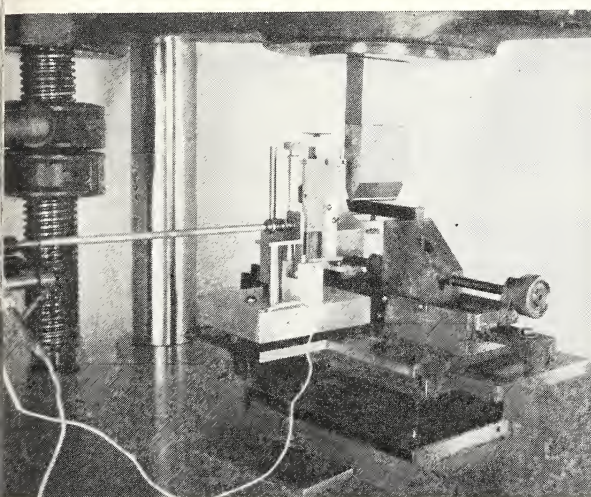
*Mechanical Properties.* The tensile, compressive, flexural, and impact properties of several types of plastic laminates, which are either in use or have potential application in aircraft structures and parts, were determined at  $-70^{\circ}$ ,  $+77^{\circ}$ , and  $+200^{\circ}$  F. The materials investigated were unsaturated-polyester laminates reinforced with glass fabric and phenolic laminates reinforced with as



Tensile strength tests on resin-bonded glass-fabric laminates are made in a universal testing machine, employing Templin grips to obtain uniform loading of the specimen. The recording extensometer attached to the specimen provides an autographic record of the stress-strain properties. These glass-fabric laminates have high tensile strengths, running up to 50,000 pounds per square inch for cross-laminated fabrics.



Hydraulic universal testing machine with electrical mechanical extensometer and autographic recorder used for determining the stress-strain properties of plastics.



A variable-span flexure test jig for plastic specimens with recording extensometer and deflection lever attached. This apparatus was designed and constructed because of the significant effect which span-depth ratio has on measurements of the flexural strength of plastics.

bestos fabric, high-strength paper, rayon fabric, and cotton fabric. Both high-pressure and low-pressure types of cotton-fabric phenolic laminates were included [101.3, 101.5, 101.6, 101.7].<sup>1</sup>

The relationship between the strengths of molded plastic articles and strength data obtained with standard test specimens was the subject of another report. Tensile, flexural, and impact properties of phenolic molding materials containing woodflour, cotton flock, macerated fabric, tire cord, asbestos, and mica fillers were studied [101.2].

Tensile, compressive, and Haigh tensile fatigue tests were conducted on a laminated paper-base plastic proposed for use in molding airplane propellers [101.1].

*Thermal Properties.* An analysis of the causes of internal stress concentrations in molded parts with metal inserts and in resin-bonded sheet materials led to the conclusion that stress concentrations can be eliminated in many cases by matching the coefficients of thermal expansion of the component parts. A stress-equilibrium formula for calculating the thermal expansion coefficients of mixtures involves the density, modulus of elasticity, coefficients of thermal expansion, and proportion by weight of the ingredients [102.1]. The thermal expansion coefficients of a number of plastics with and without fillers are reported.

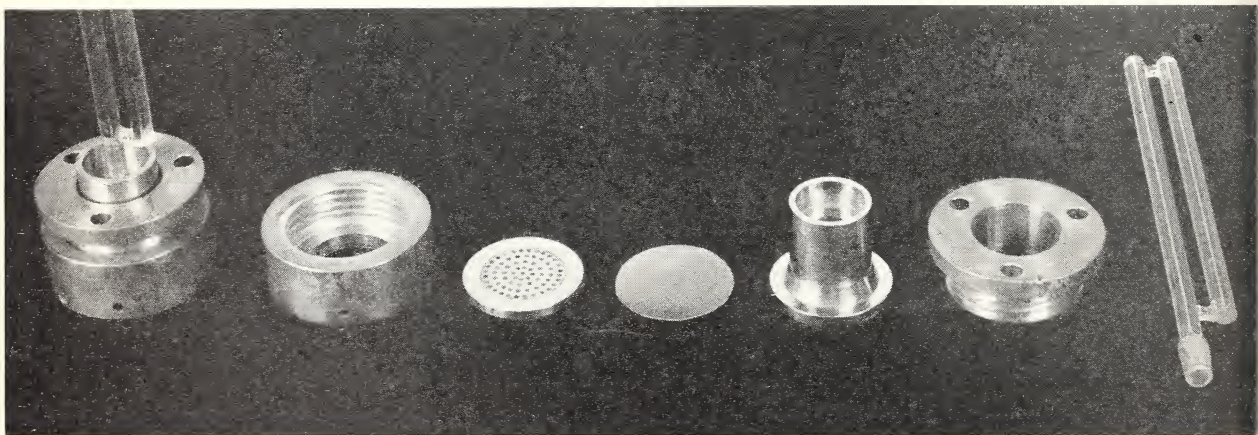
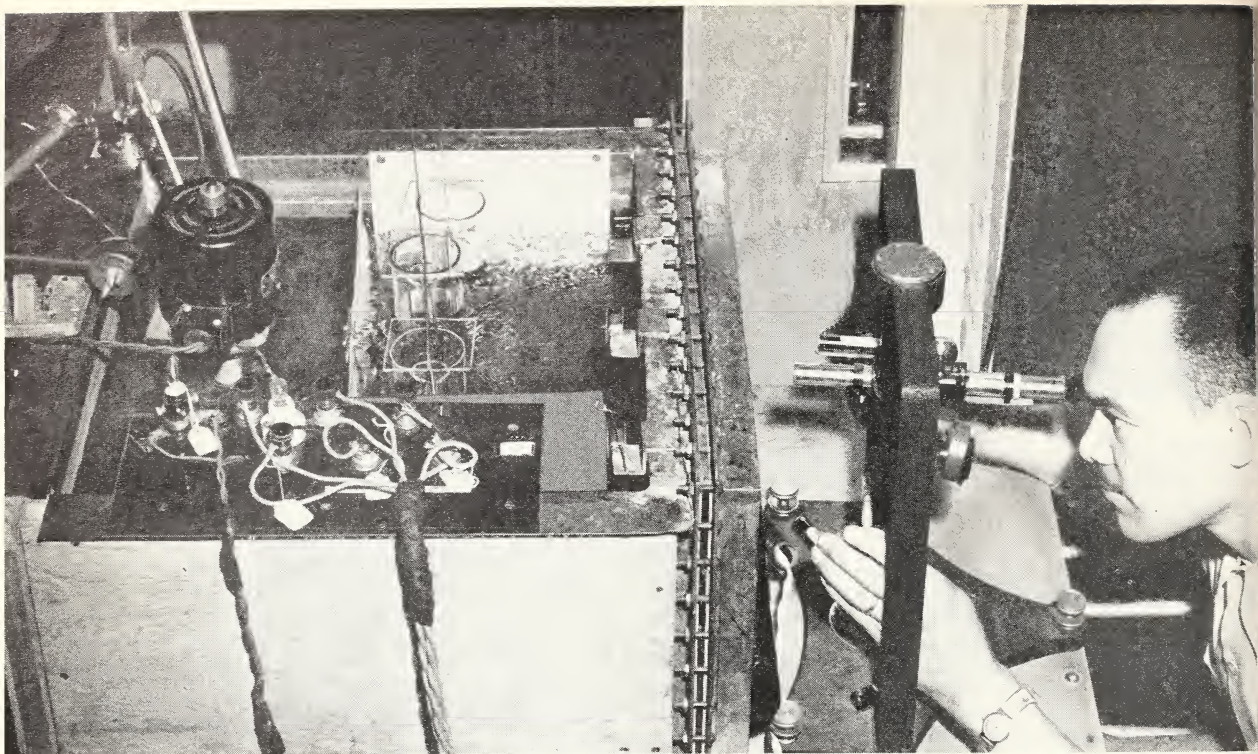
*Optical Properties.* Ultraviolet and visible light transmissions have been determined for many types of plastics, including polystyrene, polyvinyl chloride acetate, polyvinyl acetal, polymethyl methacrylate, allyl and glyceryl phthalate resins, ethylcellulose, and cellulose nitrate, acetate, acetate propionate, and acetate butyrate [103.3, 103.4]. Earlier work on ultraviolet light transmission and infrared absorption spectra of plastics is presented in two research papers [103.1, 103.2].

*Electrical Properties.* As previously mentioned, the first project on plastics at this Bureau was a study of the properties of electrical insulating materials of the laminated phenolic type [104.1]. Because of the importance of plastics as insulators in modern electronic equipment and instruments, new investigations of the electrical characteristics of these materials at ultrahigh frequencies have been undertaken recently.

*Permanence Properties.* The effects of conditions encountered in service involving exposure to moisture, heat, ultraviolet light, and chemicals are of major importance in determining the suitability of plastics in most applications. These environmental factors can lead to critical changes in dimensions and shape; crazing, cracking, or marring of surfaces; impairment of clarity; and loss of strength and insulating characteristics. Our investigations in this field have included exposure of laminates to weathering and various combinations of temperature and humidity [105.4, 105.6], resistance of plastics to chemicals [105.3] and microbiological organisms [105.5], and effects of outdoor and accelerated weathering on transparent plastics [105.2, 105.7]. The methods used in determining the effects of these deteriorating agents on plastics have been reviewed [105.1].

*Permeability.* The transmission of water vapor and gaseous materials through films of organic polymers is of significance in many fields—protective coatings, balloon fabrics, packaging and wrapping materials, and the like. Considerable work has been done on this problem at the Bureau,

<sup>1</sup> Figures in brackets indicate the literature references beginning on p. 9.



Studies of the basic properties of high polymers are conducted at the National Bureau of Standards. The apparatus shown was designed at the Bureau for determination of the molecular weight of a plastic substance by measurement of the osmotic pressure it produces in solution. Top: Measurement of the position of the meniscus in the capillary of the apparatus contained in a constant temperature bath. Bottom: Disassembled parts of the osmometer.

particularly with respect to the passage of hydrogen and helium through film-forming materials suitable for coating balloon and airship fabrics [106.1, 106.4, 106.5]. Other reports dealt with the water vapor permeability of synthetic resin finishes for aircraft [106.3] and films used in the packaging trade [106.2].

*Water Absorption.* The mechanical and electrical properties and dimensional stability of plastics are definitely affected by water absorbed by them. Low water absorption is of considerable advantage in a plastic material. The rates of

absorption and desorption of water by 16 types of plastics for periods up to two years and the concomitant dimensional changes have been determined [107.1].

## 2. Testing of Plastics

Systematic studies of the properties of plastics for the most part date back less than a decade. Hence most of the investigations described in the reports already cited involved exploratory work on the test methods used. In addition, there have



been papers dealing with the preparation of test specimens [200.3] and methods of testing transparent plastics [200.2]. A particularly noteworthy contribution was made to the testing of asphalt tile [200.1]. This paper described a portable instrument for indentation testing and presented a formula for relating the depth of indentation to the time during which a loaded sphere acts upon such a plastic body.

### 3. Chemistry of Plastics

The synthesis of pure resins for use in experimental work on the molecular structure and physical constants of high polymers is a phase of the research program at this Bureau, which has been initiated only recently. These polymers of known composition and history will be used in the evaluation of quality control methods for determining the size, shape, and weight distribution of the macromolecules and in studies to correlate composition with mechanical and electrical properties. Based on previous experience in the compilation of such data for natural rubber, this information should prove to be a fruitful source of new basic principles and new product developments in the plastics field. A fundamental investigation of the polymerization of olefins was reported some years ago [300.1, 300.2].

### 4. Plastic Materials

The experimental work on plastics at this Bureau has included practically all types of commercial materials. There are three groups of these products, however, that have been the subject of especially concentrated endeavor.

*Transparent Plastics.* Although no organic plastic has yet been developed that has the scratch resistance and low price of glass, nevertheless, transparent plastics have found many significant uses. Among the outstanding examples of these may be cited the methacrylate resin used for aircraft windows and enclosures, the polyvinyl butyral used for the interlayer in safety glass, and cellulose acetate used in the manufacture of goggles. A study of this important category of plastics was undertaken by the Organic Plastics Section when it was organized in 1935, and several reports relating to this work have been published in this country and abroad [401.1, 401.2, 401.3]. More recent investigations have been concerned with antiscatter treatments for glass to provide protection against this hazard during air raids [401.5] and with plastic mountings for windshields on airplanes having pressurized cabins [401.4].

*Laminated Plastics.* Laminates prepared by impregnating and bonding together layers of paper, cotton cloth, glass fabric, asbestos sheets, or wood veneers, are growing in significance as materials of construction for use in the aircraft, building, chemical, electrical, and other industries. Their properties have been determined in a series of extensive investigations and reported for use by design engineers [101.1, 101.3, 101.6, 102.1, 104.1, 105.3, 105.4, 107.1, 402.1]. Further work is under way to add to our knowledge of the performance characteristics of these materials, particularly at the high temperatures likely to be developed in transonic and supersonic flight.

*Expanded Plastics.* Organic polymers can be converted into low-density porous spongelike products that have thermal and sound insulating qualities. With proper strength-density ratio, they are also useful as core materials in combination with high-strength high-density facing materials in sandwich structures for aircraft. One report on the properties of expanded plastics has been published [403.1]. Further exploration of this relatively new group of materials is in progress.

### 5. Applications of Plastics

The evaluation of materials for specific end uses has been a major phase of the work on plastics at this Bureau. These activities result from the advisory function of the Bureau to other Government agencies on technical matters, particularly properties of materials and performance standards. Developments in the applications of plastics for aircraft structures and accessories have been the subject of a considerable number of investigations for the National Advisory Committee for Aeronautics and the Navy Bureau of Aeronautics. Many items of equipment were evaluated for the military services during World War II. These and other application studies are reviewed in the following sections.

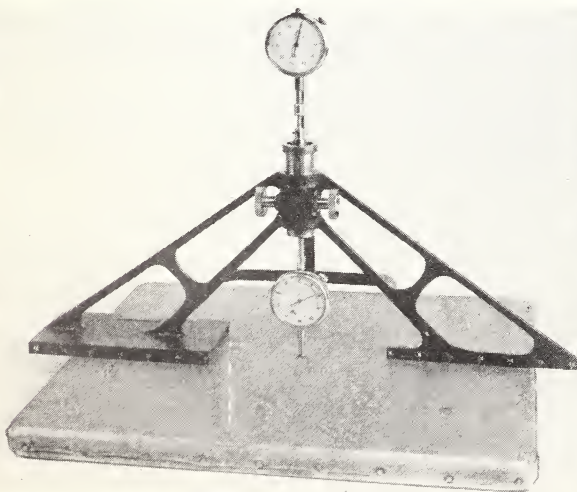
*Aircraft Construction.* The endeavor to use plastic materials as structural materials for airplanes is attributable to their low density and ease of streamlining. Following more than a decade of development work on this problem, wings and fuselages have been molded from a combination of synthetic resin and glass fabric that offers promise of providing the strength and dimensional stability required for this purpose. Several reports relating to investigations of materials of this type have been published [101.1, 101.3, 101.6, 105.4, 402.1, 501.1, 501.2, 501.3]. Plastic compositions for application to aircraft surfaces, welds, and junctions of metal plates, and to rivet depressions to improve the aerodynamic efficiency at high speeds, have been described [501.4].



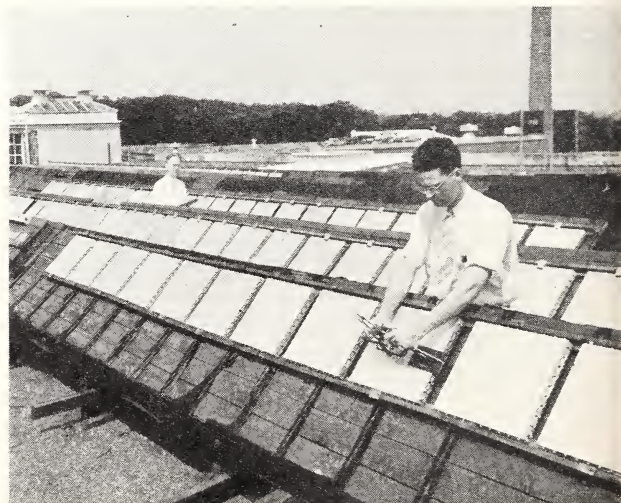
Cellulose acetate butyrate dope for fabric-covered wing and control surfaces on aircraft was developed by the National Bureau of Standards to replace the highly flammable and less durable cellulose nitrate dope. The dope developed by this Bureau was used on Navy carrier-based aircraft during World War II and has also been used extensively on light civilian airplanes. The photograph shows a tautness reading being made on a doped fabric surface of an airplane wing.

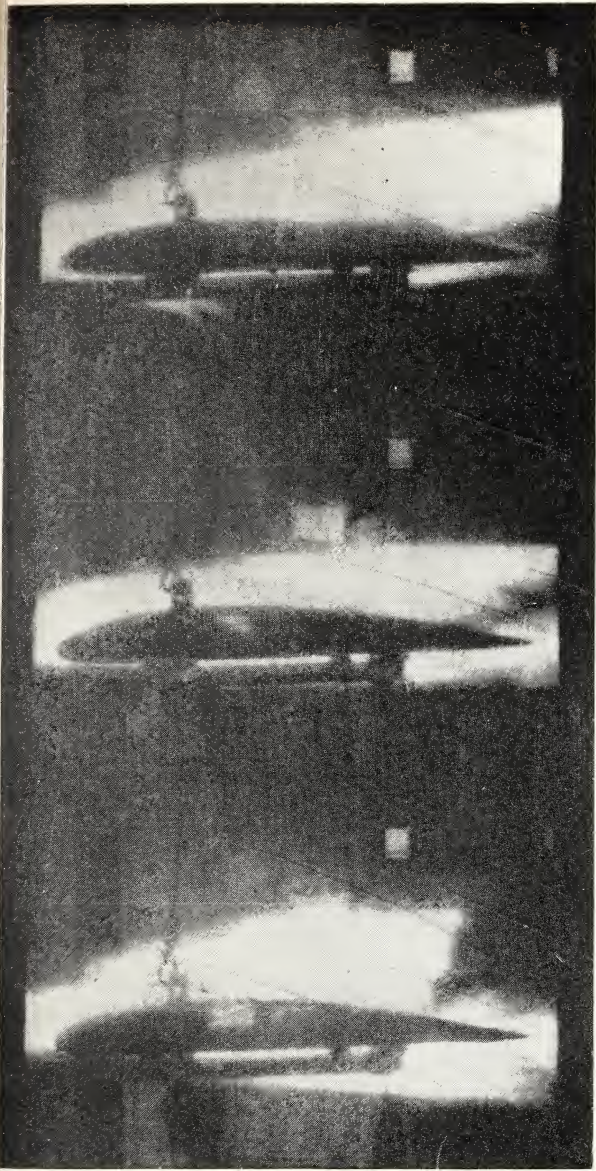
*Airplane Dopes.* The problem of developing a fire-resistant airplane dope to replace the hazardous cellulose nitrate product was undertaken in 1937 at the request of the Navy Bureau of Aeronautics. A dope based on cellulose acetate butyrate was formulated, which has been in continuous successful use on naval aircraft since 1940 [502.5, 502.8]. In addition to being less flammable, its superior resistance to deterioration under tropical weather conditions proved especially advantageous in World War II. The basic data obtained in the course of this investigation concerning the effects on film characteristics of the four variables involved in the formulation of film-forming compositions—namely, plastic, plasticizer, solvent, and diluent—have proved to be valuable in the solution of other problems involving such systems [502.7]. Earlier research showed that airplane fabric can be made resistant to ignition by application of a 3:7 boric acid borax mixture [502.2, 502.3, 502.4]. An instrument for estimating the tautness of doped fabrics on aircraft and other methods and equipment for evaluating the performance of aircraft coverings were developed during these studies [502.1, 502.6].

*Coatings for Balloon Fabrics.* Production of a suitable coating for balloon fabric that will withstand severe flexure under varying conditions of temperature and humidity and will be virtually impermeable to the lifting gas is another problem that has been worked on for the Navy Bureau of Aeronautics. In common with all structural materials employed in lighter-than-air craft, emphasis is placed upon optimum properties—strength, durability, impermeability—per unit weight of



A spring-loaded tautness meter was developed to provide a means for determining the tautness of wing and fuselage sections on the airplane itself and during their storage in vertical positions. Weight-loaded tautness meters available before the development of the spring-loaded instrument could be used only on approximately horizontal surfaces. The photographs show the tautness meter in position on a test panel and measurements being made on panels undergoing roof exposure tests.





Sample motion picture record of wind-tunnel burning tests conducted jointly by the National Bureau of Standards and the Civil Aeronautics Administration to evaluate fire-retardant coatings developed by the Bureau for fabric-covered aircraft. A steel wing section is shown suspended at the outlet of an open-type wind tunnel which provides a 70-mile-per-hour air stream. In an opening 12 inches square in the lower surface of the wing are test panels, consisting of doped fabric with fire-retardant coatings. A uniform spray of 90-octane gasoline, ignited by a high-tension spark, envelops the wing section in burning gasoline. In addition to the motion-picture record of the fire, observers provided with stop watches noted the time for destruction of the outer coating and the time of fabric failure.

fabric. A considerable number of reports pertaining to the use of synthetic rubber and other elastomers for this purpose has been issued [106.1, 106.4, 106.5, 503.1, 503.2, 503.3, 503.4].

*Dental Materials.* The American Dental Association has maintained a Research Fellowship at the National Bureau of Standards since 1928 for the investigation of dental materials. In cooperation with members of the Bureau's staff the research fellows have conducted tests of plastics marketed for use as denture bases [504.1, 504.2, 504.3, 504.4, 504.5, 504.6], liners for dentures [504.8], and teeth in full and partial dentures [504.7]. Most of these dental products were based on methyl methacrylate resin; however, the denture bases included also acrylic-styrene, acrylic-vinyl and vinyl chloride acetate copolymers, phenol-formaldehyde resin, cellulose nitrate plastic, and hard rubber.

*Resin-Bonded Map Paper.* Early in World War II a new map paper was developed that greatly improved the quality and performance of war maps. Unique properties built into this paper gave satisfactory performance in contact with the water, mud, and grime of the battlefield that had disintegrated papers used heretofore. The most important feature of the paper is its high wet strength, which is obtained by the addition of melamine-formaldehyde resin [505.1]. This Bureau cooperated with the Army Map Service of the Corps of Engineers by conducting semicommercial papermaking experiments in its paper mill to establish how to make the paper from commercially available raw materials and by assisting in the preparation of the purchase specification used by the Army [505.2, 505.3, 505.4].

*Preservation of Documents.* The suitability of cellulose sheetings as protective coverings for documents was investigated as part of a general study of problems relating to the preservation of records. Cellulose acetate film was found to have the advantages of good stability and ease of application by the use of heat and pressure [506.1, 506.2, 506.3]. When the National Archives of the United States was confronted with the necessity of preserving the vast amounts of documents transferred to it from the various Government agencies, lamination with cellulose acetate was selected as the most feasible method. Their experience during the past decade has indicated that the process is eminently satisfactory.

*Motion Picture Film.* Photographic film is another important material used for recording documents of all types. Records on this medium require only a fraction of the storage space needed for the same information on paper. Cellulose acetate film was demonstrated to be suitable for this purpose if properly made and processed [507.1, 507.2, 507.4, 507.5]. Test methods for folding endurance, pH, copper number, relative viscosity, and limiting values of quality for use in selecting such film for record purposes have been described [507.3].

*Adhesives.* The attachment of materials and parts together by adhesives is an efficient and rapid method of assembly. This use of synthetic resins is expanding and accounts for approximately 10 percent of current production [508.5]. A research project is in progress at this Bureau under the sponsorship of the Office of Naval Research to obtain a better understanding of the physical and chemical forces involved in adhesion. A comprehensive survey of the theoretical aspects of adhesion and the techniques used in evaluating bond strengths has been prepared [508.3]. Experimental phases of the project have dealt with the effects of various catalysts used to cure the resinous adhesives on the strength properties of plywood, particularly with regard to the degree of acidity developed [508.1, 508.4], and on the bonding strengths of adhesives at normal and low temperatures [508.2, 508.6].

*Miscellaneous Applications.* Wartime research on the radio proximity fuze and other electronic devices led to the development of the NBS casting resin, based on styrene, dichlorostyrene, divinylbenzene, and hydrogenated terphenyl. This resin combines the low power factor essential to high-impedance, high-frequency circuits with low dielectric constant, short polymerization period at low temperature and atmospheric pressure, high impact strength, small volume shrinkage on polymerization, dimensional and electrical stability, and low moisture absorption [509.4].

The repair of porous metal castings by sealing with synthetic resins was investigated. Of fourteen resins tested, only two showed promise for this purpose. Only fifty percent of the castings subjected to one treatment with either one of these two resins was sealed; a second impregnation increased the sealing efficiency to 80 percent [509.3].

The critical supply situation with respect to sole leather during World War II, attributable to both increased demands by the military services and dependence to a large extent on foreign sources for hides and tanning materials, made it necessary for the War Production Board to seek replacements wherever possible. Plastics based on vinyl resins were found to have suitable properties for this application [509.2].

In April 1942 the Joint Optics Committee of the Army-Navy Munitions Board held a meeting to discuss possible replacement materials for the aluminum used in binocular bodies, aluminum being at that time among the more critical materials. It was recommended that a binocular housing be fabricated from a plastic material. The development work on this problem was carried on jointly by the U. S. Naval Observatory and this Bureau. Binoculars were fabricated with phenolic-asbestos housings that satisfactorily fulfilled all of the re-



A plastic housing for a 6×42 binocular was developed during World War II in a cooperative project of the U. S. Naval Observatory and the National Bureau of Standards. The optical system for this binocular was designed by the Optical Instruments Section. A similar cooperative project on a plastic carrying case made of fabric impregnated with a phenolic resin and coated with a vinyl resin provided a container superior to the former leather case in resistance to fungus, moisture, and abrasion.

quirements for a general-purpose service instrument [509.1].

## 6. Specifications for Plastics

The 1,311-page National Directory of Commodity Specifications [600.2] and 322-page Supplement [600.3] prepared at this Bureau devote several pages to specifications for plastic products. Each standard or specification is listed by title, designating number, and sponsoring organization. A summary is given of the technical characteristics, scope, and special applications.

The many different plastic products used by the Federal Government from drawing instruments to tableware are purchased under Federal Specifications that set standards of quality, performance, and dimensions. The general methods of testing for plastic products are described in Federal Specification L-P-406a [600.1]. Members of the staff of this Bureau participate in the preparation of these specifications.

## 7. General Information on Plastics

In addition to its work for other Government agencies, the Bureau is required "to supply available information to the public, upon request, in the fields of physics, chemistry, and engineering." Individuals and small-business firms constantly are asking for assistance. They are furnished information on specific topics relating to plastics or given references to other sources of information.

To facilitate performance of this function, surveys of the materials, methods of fabrication, and applications of plastics [701.1 to 701.10], annual reviews of developments [702.1 to 702.10], and reports on special subjects have been prepared. The latter have included the significance of plastics to the building [703.3, 703.5] and food container [703.1] industries, and the potential production of plastics from lignin-containing substances [703.4] and petroleum [703.2].

## 8. Investigation of German Technology

The conversion of nature's raw materials by synthesis into a myriad of useful products has always been a special forte of scientists in Germany, the birthplace of organic chemistry. Their

efforts toward attaining self-sufficiency in domestic supplies of fuels, oils, rubbers, textiles, and fats are well known to the world. Similarly, in the synthetic resin field their scientists have developed many of the compounds that are used for the production of molded plastics, films and foils, improved leather-type goods, and protective coatings. An investigation of the formulations, manufacturing processes, fabricating techniques, and applications of plastics in Germany was made by the Chief of the Organic Plastics Section in 1945 under the auspices of the Office of the Chief of Ordnance, War Department. The information obtained has been made available to the American public in the form of surveys [801.1 to 801.3], special subject reports [802.1 to 802.8], and translations of important technical documents [803.1 to 803.15].

## III. Bibliography

This section lists 160 published reports, prepared by members of the staff of this Bureau, arranged under the same headings used in the preceding text. The titles of the publications show the scope of its research and technological investigations on plastics. Many other reports of limited interest have been submitted to other Government agencies and given circulation at the discretion of those agencies.

A large number of the reports listed are Government publications available from the Superintendent of Documents, Government Printing Office, Washington 25, D. C., at the prices indicated. The prices quoted are for delivery to addresses in the United States and its territories and possessions and in certain foreign countries that extend the franking privilege. In the case of all other countries, one-third the cost of publication should be added to cover postage. Remittances can be made very conveniently by coupons obtainable from the Superintendent of Documents in sets of 20 for \$1.00, good until used. Checks and money orders should be made payable to "Superintendent of Documents, Government Printing Office" and sent to him with each order. The Government Printing Office does not accept stamps in payment of orders. A quantity discount of 25 percent is given on orders for a single publication purchased in lots of 100 copies. Publications marked "(OP)" are out of print and are consequently no longer available. They may in general be consulted in technical and public libraries.

The NACA publications are available in limited quantity from the National Advisory Committee for Aeronautics, 1724 F Street NW., Washington 25, D. C.

The PB (Publication Board) reports are available from the Library of Congress, Photoduplication Service, Publication Board Project, Washington 25, D. C., in microfilm (mf.) or photostat (ph.)

form at the prices indicated. Orders should be sent to the above address with check or money order made payable to the Librarian of Congress.

Neither the Government Printing Office nor the National Bureau of Standards is in a position to supply copies of the nongovernmental technical and trade journals mentioned in the bibliography or reprints from them. Information regarding their availability and price can be furnished by the publisher or organization sponsoring the publication. Their addresses can be obtained from the "List of Periodicals Abstracted" in part 2 of the December 20, 1946, issue of Chemical Abstracts. The name and location of libraries where these journals can be consulted can also be found in this same list.

## 100. Properties of Plastics

### 101. Mechanical

- [101.1] Strength and fatigue tests on a laminated paper-base plastic proposed for use in molding propellers. B. M. Axilrod, NACA Advance Restricted Report (Aug. 1942).
- [101.2] Correlation between strength properties in standard test specimens and molded phenolic parts. P. S. Turner and R. H. Thomason. NACA Tech. Note No. 1005 (May 1946). *Modern Plastics* **23**, 146 (May) and 154 (July 1946).
- [101.3] Impact strength and flexural properties of laminated plastics at high and low temperatures. J. J. Lamb, I. Albrecht, and B. M. Axilrod. NACA Tech. Note No. 1054 (Aug. 1946).
- [101.4] Tensile properties of rolled silver chloride. B. M. Axilrod and J. J. Lamb. *J. Applied Phys.* **19**, 213 (1948).
- [101.5] Tensile stress-strain relationship of laminated plastics at small strains. J. J. Lamb and B. M. Axilrod. *ASTM Bulletin* No. 151, 59 (Mar. 1948).
- [101.6] Tensile and compressive properties of laminated plastics at high and low temperatures. J. J. Lamb, I. Albrecht, and B. M. Axilrod. NACA Tech. Note No. 1550 (July 1948).

- [101.7] Mechanical properties of laminated plastics at  $-70^{\circ}$ ,  $77^{\circ}$ , and  $200^{\circ}$  F. J. J. Lamb, I. Albrecht, and B. M. Axilrod. *J. Research NBS* **43**, 257 (1949) RP202S (20¢).

### 102. Thermal

- [102.1] Problem of thermal-expansion stresses in reinforced plastics. P. S. Turner. NACA Advance Restricted Report (June 1942). *J. Research NBS* **37**, 239 (1946) RP1745 (10¢). *Modern Plastics* **24**, 153 (Dec. 1946).
- [102.2] Discussion of paper on the ignition temperature of rigid plastics. N. P. Setchkin. *ASTM Bulletin* No. 151, 66 (Mar. 1948).

### 103. Optical

- [103.1] Data on ultraviolet solar radiation and the solarization of window materials. W. W. Coblenz and R. Stair. *J. Research NBS* **3**, 629 (1929) RP113 (15¢).
- [103.2] Infrared absorption spectra of plant and animal tissue and various other substances. R. Stair and W. W. Coblenz. *J. Research NBS* **15**, 295 (1935) RPS30 (5¢).
- [103.3] Ultraviolet and visible light transmission by various plastics. *Modern Plastics Encyclopedia*, p. 756 (1947).
- [103.4] Infrared prism spectrometry from 24 to 40 microns. E. K. Plyler. *J. Research NBS* **41**, 125 (1948) RP1911 (10¢).

### 104. Electrical

- [104.1] Properties of electrical insulating materials of the laminated phenol-methylene type. J. H. Dellinger and J. L. Preston. *Tech. Pap. BS* **16**, 501 (1922) T216 (OP).

### 105. Permanence

- [105.1] Permanence of plastics. G. M. Kline. *ASTM Symposium on Plastics*, 51 pages (1938). *Modern Plastics* **15**, 47 (April), 46 (May) and 40 (June 1938).
- [105.2] Accelerated weathering of transparent plastics. G. M. Kline, W. A. Crouse, and B. M. Axilrod. *Proc. ASTM* **40**, 1256 (1940). *Modern Plastics* **17**, 49 (Aug. 1940).
- [105.3] Resistance of plastics to chemical reagents. G. M. Kline, R. C. Rinker, and H. F. Meindl. *Proc. ASTM* **41**, 1246 (1941). *Modern Plastics* **19**, 59 (Dec. 1941). *British Plastics* **14**, 478 (1943).
- [105.4] Effect of simulated service conditions on plastics. W. A. Crouse, D. C. Caudill, and F. W. Reinhart. NACA Tech. Note No. 1240 (July 1947).
- [105.5] Microbiological deterioration of organic materials: its prevention and methods of tests. E. Abrams. *Misc. Pub. NBS* M188 (1948) (25¢).
- [105.6] Effect of simulated service conditions on plastics during accelerated and 2-year weathering tests. W. A. Crouse, D. C. Caudill, F. W. Reinhart. NACA Tech. Note No. 1438 (May 1948).
- [105.7] Degradation of plastics. F. W. Reinhart. *SPE News* **4**, 3 (Sept. 1948).

### 106. Permeability

- [106.1] Permeability of synthetic film-forming materials to hydrogen. T. P. Sager. *J. Research NBS* **13**, 879 (1934) RP750 (5¢).
- [106.2] Permeability of membranes to water vapor with special reference to packaging materials. F. T. Carson. *Misc. Pub. NBS* M127 (1937) (5¢).

- [106.3] Permeability to moisture of synthetic resin finishes for aircraft. G. M. Kline. *J. Research NBS* **13**, 235 (1937) RP974 (5¢).

- [106.4] Permeability of organic polysulfide resins to hydrogen. T. P. Sager. *J. Research NBS* **19**, 181 (1937) RP1020 (5¢).

- [106.5] Permeability of elastic polymers to hydrogen. T. P. Sager. *J. Research NBS* **25**, 309 (1940) RP1327 (5¢).

### 107. Water Absorption

- [107.1] Sorption of water by plastics. G. M. Kline, A. R. Martin, and W. A. Crouse. *Proc. ASTM* **40**, 1273 (1940). *Modern Plastics* **18**, 119 (Oct. 1940).
- [107.2] Sorption of nitrogen and water vapor on textile fibers. J. W. Rowen and R. L. Blaine. *Ind. Eng. Chem.* **39**, 1659 (1947).

### 200. Testing of Plastics

- [200.1] Indentation of asphalt tile. J. W. McBurney. *Proc. ASTM* **34**, part II, 591 (1934).
- [200.2] Methods of testing plastics. G. M. Kline and B. M. Axilrod. *Ind. Eng. Chem.* **28**, 1170 (1936). *Modern Plastics* **14**, 35 (Jan. 1937).
- [200.3] Preparation of test specimens with a diamond-impregnated cutting wheel. F. W. Reinhart. *Modern Plastics* **22**, 151 (June 1945).
- [200.4] A variable-span flexure test jig for plastic specimens. B. M. Axilrod, R. W. Thiebeau, and G. M. Brenner. *ASTM Bulletin* No. 148, 96 (Oct. 1947).
- [200.5] Measurement of the slipperiness of walkway surfaces. P. A. Sigler, M. N. Geib, and T. H. Boone. *J. Research NBS* **40**, 339 (1948) RP339 (10¢).
- [200.6] Light-sensitive papers as controls for testing textile color-fastness and stability of materials under arc lamp exposure. H. F. Launer, J. Research NBS **41**, 169 (1948) RP1916 (10¢).
- [200.7] Pump for volatile and toxic liquids in viscometers. J. W. McElwain. *Analytical Chem.* **21**, 194 (1949).
- [200.8] Diphenylamine test for nitrates in mixtures of cellulose esters. A. G. Roberts. *Analytical Chem.* **21**, 813 (1949).

### 300. Chemistry of Plastics

- [300.1] Polymerization of olefins formed by the action of sulfuric acid on methylisopropylcarbinol. G. M. Kline and N. L. Drake. *J. Research NBS* **13**, 705 (1934) RP740 (5¢).
- [300.2] The diamylenes produced from methylisopropylcarbinol by sulfuric acid. N. L. Drake, G. M. Kline, and W. G. Rose. *J. Am. Chem. Soc.* **56**, 2076 (1934).
- [300.3] Reactivity ratios in diene and diene-vinyl copolymerization. L. A. Wall. *J. Polymer Sci.* **2**, 542 (1947).
- [300.4] Heats of combustion and solution of liquid styrene and solid polystyrene, and the heat of polymerization of styrene. D. E. Roberts, W. W. Walton, and R. S. Jessup. *J. Research NBS* **38**, 627 (1947) RP1801 (10¢).
- [300.5] Absorption spectra in the detection of chemical changes in cellulose and cellulose derivatives. J. W. Rowen, C. M. Hunt, and E. K. Plyler. *J. Research NBS* **39**, 133 (1947) RP1816 (10¢).
- [300.6] Note on volume effect in coiling molecules. R. Simha. *J. Research NBS* **40**, 21 (1948) RP1852 (5¢). *J. Polymer Sci.* **3**, 227 (1948).
- [300.7] Substituted styrenes modify polymer properties. F. W. Reinhart. *Chem. Industries* **62**, 235 (1948).

- [300.8] Pyrolytic fractionation of polystyrene in a high vacuum and mass spectrometer analysis of some of the fractions. S. L. Madorsky and S. Straus. *J. Research NBS* **40**, 417 (1948) RP1886 (10¢).
- [300.9] Mass spectrometric investigation of the thermal decomposition of polymers. L. A. Wall. *J. Research NBS* **41**, 315 (1948) RP1928 (10¢).
- [300.10] Copolymerization. R. Simha and L. A. Wall. *J. Research NBS* **41**, 521 (1948) RP1937 (15¢).
- [300.11] Effect of concentration on the viscosity of dilute solutions. R. Simha. *J. Research NBS* **42**, 409 (1949) RP1981 (10¢).

## 400. Plastic Materials

### 401. Transparent Plastics

- [401.1] Transparent plastics for aircraft windows. G. M. Kline. *Ind. Eng. Chem., News Ed.* **13**, 479 (1935). *Modern Plastics* **13**, 17 (Jan. 1936).
- [401.2] Study of transparent plastics for use on aircraft. B. M. Axilrod and G. M. Kline. *J. Research NBS* **19**, 367 (1937) RP1031 (15¢). *Modern Plastics* **15**, 65 (Nov. 1937). *Rev. de l'Armée de l'Air* **1938**, No. 107, 667.
- [401.3] Resistance of transparent plastics to impact. B. M. Axilrod and G. M. Kline. *NACA Tech. Note No. 718* (July 1939).
- [401.4] Plastic mountings for aircraft windshields. K. H. Bradley, B. M. Axilrod, and G. M. Kline. *NACA Tech. Note No. 936* (May 1944).
- [401.5] Antiscatter treatments for glass. F. W. Reinhart, R. A. Kronstadt, and G. M. Kline. *Misc. Pub. NBS M175* (1944) (10¢).
- [401.6] Spectral-transmissive properties and use of eye-protective glasses. R. Stair. *Circ. NBS* **471** (1948) (20¢).

### 402. Laminated Plastics

- [402.1] Properties of reinforced plastics and plastic plywoods. G. M. Kline, B. M. Axilrod, and P. S. Turner. *NACA Advance Restricted Report* (July 1941).

### 403. Expanded Plastics

- [403.1] Properties of some expanded plastics and other low-density materials. B. M. Axilrod and E. Koenig. *NACA Tech. Note No. 991* (Sept. 1945). *Plastics (Chicago)* **5**, 68 (July 1946).

## 500. Applications of Plastics

### 501. Aircraft Construction

- [501.1] Plastics as structural materials for aircraft. G. M. Kline. *NACA Tech. Note No. 628* (Dec. 1937).
- [501.2] Plastics as structural materials for aircraft. G. M. Kline. *J. Aeronaut. Sci.* **5**, 391 (1938). *Modern Plastics* **15**, 35 (Aug.); **16**, 44 (Sept. 1938). *Commercial Aviation (Canada)* **1**, 19 (May) and 21 (June 1939).
- [501.3] Plastic materials for aircraft structures. B. M. Axilrod, P. S. Turner, F. W. Reinhart, and G. M. Kline. *NACA Advance Restricted Report* (July 1942).
- [501.4] Fairing compositions for aircraft surfaces. P. S. Turner, J. Doran, and F. W. Reinhart. *NACA Tech. Note No. 958* (Nov. 1944).

### 502. Airplane Dopes

- [502.1] Estimation of tautness of doped fabrics. G. M. Kline. *Am. Paint and Varnish Mfrs.' Assn. Cir. No. 443*, 266 (1933).
- [502.2] Fire-resistant fabric for aircraft. G. M. Kline. *Sci. Monthly* **41**, 190 (1935).
- [502.3] Airplane fabrics and dopes. G. M. Kline. *Aero Digest* **27**, No. 1, 38 (1935).
- [502.4] Fire-resistant doped fabric for aircraft. G. M. Kline. *J. Research NBS* **14**, 575 (1935) RP788 (5¢). *Ind. Eng. Chem.* **27**, 556 (1935).
- [502.5] Suitability of various plastics for use in airplane dopes. G. M. Kline and C. G. Malmberg. *J. Research NBS* **20**, 651 (1938) RP1098 (5¢). *Ind. Eng. Chem.* **30**, 542 (1938).
- [502.6] An instrument for estimating tautness of doped fabrics on aircraft. G. M. Kline and H. F. Schiefer. *NACA Tech. Note No. 729* (Sept. 1939).
- [502.7] Film-forming plastics: effect of solvents, diluents, and plasticizers. F. W. Reinhart and G. M. Kline. *Ind. Eng. Chem.* **31**, 1522 (1939).
- [502.8] Airplane dopes: relation of tautening and weathering qualities to composition. F. W. Reinhart and G. M. Kline. *Ind. Eng. Chem.* **32**, 185 (1940).
- [502.9] The development of fire-retardant coatings for fabric covered aircraft. S. G. Weissberg, H. L. Hansberry, and G. M. Kline. *Civil Aeronautics Administration Technical Development Report No. 86* (Oct. 1948). *Ind. Eng. Chem.* **41**, 1742 (1949).

### 503. Coatings for Balloon Fabrics

- [503.1] Absorption of moisture by aeronautical textiles. G. M. Kline. *Am. Dyestuff Repr.* **24**, 4 (Jan. 14, 1935).
- [503.2] Moisture relations of aircraft fabrics. G. M. Kline. *J. Research NBS* **14**, 67 (1935) RP758 (5¢).
- [503.3] Effect of protective coatings on the absorption of moisture by gelatin-latex gas-cell fabrics. D. F. Houston. *J. Research NBS* **15**, 163 (1935) RP818 (5¢).
- [503.4] Rubber substitutes as coatings for balloon fabrics. T. P. Sager. *J. Aeronaut. Sci.* **3**, 63 (1935).

### 504. Dental Materials

- [504.1] Preliminary tests of some of the newer denture materials. R. Barber. *J. Am. Dental Assoc.* **21**, 1969 (1934).
- [504.2] Progress report on denture base materials (1935). W. T. Sweeney and I. C. Schoonover. *J. Am. Dental Assoc.* **23**, 1498 (1936). *Modern Plastics* **14**, 38 (Dec. 1936).
- [504.3] Some properties of two types of resins used for dentures. I. C. Schoonover and W. T. Sweeney. *J. Am. Dental Assoc.* **25**, 1487 (1938).
- [504.4] Denture base material: acrylic resins. W. T. Sweeney. *J. Am. Dental Assoc.* **26**, 1863 (1939).
- [504.5] Tentative American Dental Association Specification No. 12 for denture base material, acrylic resin or mixtures of acrylic and other resins. W. T. Sweeney and G. C. Paffenberger. *J. Am. Dental Assoc.* **28**, 325 (1941). Revision of Specification. *J. Am. Dental Assoc.* **29**, 127 (1942).
- [504.6] Acrylic resins for dentures. W. T. Sweeney, G. C. Paffenberger, and J. R. Beall. *J. Am. Dental Assoc.* **29**, 7 (1942). *Modern Plastics* **19**, 61 (Apr. 1942).

- [504.7] Wear of acrylic resin teeth (Progress Report). J. R. Beall. *J. Am. Dental Assoc.* **30**, 252 (1943).
- [504.8] Liners for dentures. J. R. Beall and H. J. Caul. *J. Am. Dental Assoc.* **33**, 304 (1946).

### 505. Resin-Bonded Paper

- [505.1] Wet-strength papers for modern war maps. C. G. Weber. *Chem. & Met. Eng.* **52**, 109 (Mar. 1945).
- [505.2] Notes on resin-bonded wet-strength papers. C. G. Weber. *Printing Equipment Engineer* **70**, 38 (Aug. 1945).
- [505.3] Experimental manufacture of paper for war maps. C. G. Weber and M. B. Shaw. *J. Research NBS* **37**, 325 (1946) RP1751 (10¢).
- [505.4] Resin bonding and strength development in offset papers. C. G. Weber, M. B. Shaw, M. J. O'Leary, and J. K. Missimer. *J. Research NBS* **40**, 427 (1948) RP1887 (10¢). *Paper Industry and Paper World* **30**, 83 (Apr. 1948).

### 506. Preservation of Documents

- [506.1] Preservation of newspaper records. B. W. Scribner. *Misc. Pub. BS M145* (1934) (5¢).
- [506.2] Summary report of National Bureau of Standards research on preservation of records. A. E. Kimberley and B. W. Scribner. *Misc. Pub. NBS M154* (1937) (10¢).
- [506.3] The protection of documents with cellulose acetate sheeting. B. W. Scribner. *Misc. Pub. NBS M168* (1940) (5¢).

### 507. Motion Picture Film

- [507.1] Care of filmstrips and motion-picture films in libraries. C. G. Weber and J. R. Hill. *J. Research NBS* **17**, 733 (1936) RP942 (5¢).
- [507.2] Stability of motion-picture films as determined by accelerated aging. J. R. Hill and C. G. Weber. *J. Research NBS* **17**, 871 (1936) RP950 (5¢).
- [507.3] Evaluation of motion-picture film for permanent records. J. R. Hill and C. G. Weber. *Misc. Pub. NBS M158* (1937) (5¢).
- [507.4] Stability of the viscose type of ozaphane photographic film. A. M. Sookne and C. G. Weber. *J. Research NBS* **21**, 347 (1938) RP1134 (5¢).
- [507.5] Summary report of research at the National Bureau of Standards on the stability and preservation of records on photographic film. B. W. Scribner. *Misc. Pub. NBS M162* (1939) (10¢).

### 508. Adhesives

- [508.1] Effect of pH on strength of resin bonds. R. C. Rinker, F. W. Reinhart, and G. M. Kline. *NACA Advance Restricted Report No. 3J11* (Oct. 1943).
- [508.2] Bonding strengths of adhesives at normal and low temperatures. B. M. Axilrod and D. H. Jirauch. *NACA Tech. Note No. 964* (Jan. 1945).
- [508.3] Survey of adhesives and adhesion. R. C. Rinker and G. M. Kline. *NACA Tech. Note, No. 989* (Aug. 1945). *Modern Plastics* **23**, 153 (Oct.) and 164 (Nov. 1945).
- [508.4] Effect of catalysts and pH on strength of resin-bonded plywood. G. M. Kline, F. W. Reinhart, R. C. Rinker, and N. J. DeLollis. *NACA Tech. Note No. 1161* (Apr. 1947). *J. Research NBS* **37**, 281 (1946) RP1748 (15¢). *Modern Plastics* **24**, 123 (July 1947).
- [508.5] Industrial adhesives. N. J. DeLollis. *Product Eng.* **18**, 117 (Nov.) and 137 (Dec. 1947).

- [508.6] Comparative strengths of some adhesive-adherend systems. N. J. DeLollis, Nancy Rucker, and J. E. Wier. *NACA Technical Note No. 1863* (Mar. 1949).

### 509. Miscellaneous Applications

- [509.1] The plastic combat binocular. W. R. Bailey and G. M. Kline. *Modern Plastics* **22**, 105 (Oct. 1944).
- [509.2] Properties of vinyl shoe sole materials. G. M. Kline, P. A. Sigler, and P. Plaia. *Modern Plastics* **22**, 100 (July 1945).
- [509.3] A study of resinous sealants for porous metal castings. V. C. F. Holm. *J. Research NBS* **37**, 177 (1946) RP1740 (10¢).
- [509.4] Electronic applications with a new casting resin. P. J. Franklin and M. Weinberg. *Plastics (Chicago)* **7**, 57 (July 1947).
- [509.5] Cast resin for high-impedance circuits. P. J. Franklin and M. Weinberg. *Modern Plastics* **24**, 99 (July 1947).
- [509.6] Printed circuit techniques. C. Brunetti and R. W. Curtis. *Circ. NBS C468* (1947) (25¢).
- [509.7] New advances in printed circuits. Edited by C. Brunetti. *Misc. Pub. NBS M192* (1948) (40¢).
- [509.8] Treatment of leather with synthetic resins. R. Oehler and T. J. Kilduff. *J. Research NBS* **42**, 63 (1949) RP1951 (10¢).

### 600. Specifications for Plastics

- [600.1] Federal Specification for plastics, organic; general specifications, test methods. *Federal Standard Stock Catalog Item L-P-406a*, Jan. 24, 1944; Amendment-1, Apr. 15, 1949 (15¢).
- [600.2] National directory of commodity specifications, prepared by Paul A. Cooley and Ann E. Rapuzzi under the direction of A. S. McAllister. *NBS Miscellaneous Publication M178* (1945) (\$4.00).
- [600.3] Supplement to national directory of commodity specifications, prepared by Paul A. Cooley under the direction of G. N. Thompson. *NBS Miscellaneous Publication M178*, Supplement (1947) (\$2.25).
- [600.4] Federal Specification for plastics; cellulose acetate, molded. *Federal Standard Stock Catalog Item L-P-344*, May 2, 1949 (5¢).
- [600.5] Federal Specification for plastics; cellulose acetate butyrate, molded. *Federal Standard Stock Catalog Item L-P-349*, May 2, 1949 (5¢).
- [600.6] Federal Specification for plastics; cellulose nitrate (pyroxylin) sheets, rods, and tubes. *Federal Standard Stock Catalog Item L-P-365*, May 2, 1949 (5¢).
- [600.7] Federal Specification for plastics; polystyrene, molded. *Federal Standard Stock Catalog Item L-P-416*, May 2, 1949 (5¢).
- [600.8] Federal Specification for plastics; polyvinyl chloride-acetate, molded. *Federal Standard Stock Catalog Item L-P-490*, May 2, 1949 (5¢).
- [600.9] Federal Specification for plastics; polyvinylidene chloride (saran), molded. *Federal Standard Stock Catalog Item L-P-501*, May 2, 1949 (5¢).

### 700. General Information on Plastics

#### 701. Surveys

- [701.1] Organic plastics. G. M. Kline. *Circ. NBS C411* (1936) (5¢).
- [701.2] Classification and chemical genetics of organic plastics. G. M. Kline. *Trans. Electrochem. Soc.* **74**, 23 (1939). *Modern Plastics* **16**, 46 (June), 52 (July), and 48 (Aug. 1939).



- [701.3] History of plastics and their uses in the automotive industry. G. M. Kline. *J. Soc. Automotive Engrs.* **46**, 198 (1940). *Modern Plastics* **17**, 49 (July) and 58 (Aug.); **18**, 64 (Sept. 1940).
- [701.4] Plastics. G. M. Kline. *Doubleday's Encyclopedia*, 1943 Edition, **8**, 368.
- [701.5] Plastics. G. M. Kline. *Encyclopedia Americana*, 1943 Edition, **22**, 222.
- [701.6] Organic plastics. F. W. Reinhart and G. M. Kline. Chapter in *Medical Physics*, edited by Otto Glasser. (Year Book Publishers, Chicago, Ill., 1944).
- [701.7] Summary of properties, uses, and salient features of families of plastics. Introduction and conclusion to summary. G. M. Kline. *ASTM Symposium on Plastics*, 1944, pp. 136 to 139, 199 to 200.
- [701.8] The chemists' wonderland; plastics through the looking glass. G. M. Kline. *Chem. Eng. News* **22**, S90 (1944).
- [701.9] Types of plastics. G. M. Kline. *Stores* **29**, 32 (Mar. 1947).
- [701.10] Plastics. G. M. Kline. Chapter in *International industry yearbook 1948* (Kristen-Browne Publishing Co., Inc., New York, N. Y.).

### 702. Annual Reviews

- [702.1] Plastics. G. M. Kline. Chapter in *The progress of science. A review of 1940*, edited by H. H. Sheldon and S. E. Farquhar (The Grolier Society, New York, N. Y., 1941). *Annual Report of the Smithsonian Institution* **1941**, 225.
- [702.2] Advances in plastics during 1940. G. M. Kline. *Modern Plastics* **18**, 53 (Jan. 1941). *Mech. Eng.* **63**, 195 (1941).
- [702.3] Plastics. G. M. Kline. Chapter in *The progress of science. A review of 1941*, edited by H. H. Sheldon and S. E. Farquhar (The Grolier Society, New York, N. Y., 1942).
- [702.4] Advances in plastics during 1941. G. M. Kline. *Modern Plastics* **19**, 57 (Jan. 1942). *Mech. Eng.* **64**, 295 (1942).
- [702.5] Advances in plastics during 1942. G. M. Kline. *Modern Plastics* **20**, 85 (Jan. 1943). *India Rubber World* **107**, 575 (1943). *Mech. Eng.* **65**, 245 (1943).
- [702.6] Advances in plastics during 1943. G. M. Kline. *Modern Plastics* **21**, 123 (Jan. 1944). *India Rubber World* **109**, 468 (1944).
- [702.7] Advances in plastics during 1944. G. M. Kline. *Modern Plastics* **22**, 93 (Jan. 1945). *India Rubber World* **111**, 694 (1945). *Mech. Eng.* **67**, 255 (1945).
- [702.8] Advances in plastics during 1945. G. M. Kline. *Modern Plastics* **23**, 161 (Jan. 1946).
- [702.9] Plastics. G. M. Kline. *Ind. Eng. Chem.* **39**, 1234 (1947).
- [702.10] Plastics. G. M. Kline. *Ind. Eng. Chem.* **40**, 1804 (1948).

### 703. Special Subjects

- [703.1] Plastics and the tin can industry. G. M. Kline. *Modern Plastics* **13**, 36 (June 1936).
- [703.2] Synthetic resins from petroleum. G. M. Kline. *Modern Plastics* **14**, 34 (Sept. 1936).
- [703.3] New construction materials and techniques. G. M. Kline. *Modern Plastics* **14**, 44 (Nov. 1936).
- [703.4] Lignin and lignin plastics (a review). G. M. Kline. *Modern Plastics* **14**, 39 (Apr.) and 46 (May 1937).
- [703.5] Plastics and the building industry. G. M. Kline. *Plastics (Chicago)* **6**, 30 (Feb. 1947).

## 800. Investigation of German Technology

### 801. Surveys

- [801.1] Plastics in Germany, 1939-1945. G. M. Kline. OTS PB 28316, 78 pages (1945) (Mimeograph 50¢). *Modern Plastics* **23**, 152A (Oct. 1945).
- [801.2] Investigation of German plastics plants, part 1. G. M. Kline, J. H. Rooney, J. W. C. Crawford, T. Love, and F. J. Curtis. OTS PB 949, 186 pages (1945) (mf. \$2.00; ph. \$13.00).
- [801.3] Investigation of German plastics plants, part 2. J. H. Rooney, G. M. Kline, J. W. C. Crawford, T. W. M. Pond, T. Love, and R. H. Richardson. OTS PB 25642, 307 pages (1946) (mf. \$7.00; ph. \$21.00).

### 802. Special Subjects

- [802.1] Summary of German lacquer resins, solvents, and plasticizers. G. M. Kline. OTS PB 1341, 17 pages (1945) (mf. 50¢; ph. \$2.00). *Modern Plastics* **23**, 157 (Dec. 1945).
- [802.2] Adhesives in Germany. G. M. Kline. OTS PB 1343, 13 pages (1945) (mf. 50¢; ph. \$1.00). *Modern Plastics* **23**, 157 (Dec. 1945).
- [802.3] Polyvinyl alcohol in Germany. G. M. Kline. OTS PB 1344, 13 pages (1945) (mf. 50¢; ph. \$1.00). *Modern Plastics* **23**, 165 (Jan. 1946).
- [802.4] Manufacture of compreg in Germany. R. Richardson and G. M. Kline. OTS PB 1137, 17 pages (1946) (mf. 50¢; ph. \$2.00). *Modern Plastics* **23**, 155 (Mar. 1946).
- [802.5] Manufacture of vulcanized fibre in Germany. G. M. Kline and R. Richardson. OTS PB 13559, 12 pages (1946) (mf. 50¢; ph. \$1.00). *Modern Plastics* **23**, 196 (Apr. 1946).
- [802.6] Manufacture of Koresin in Germany. G. M. Kline. OTS PB 27444, 5 pages (1946) (mf. \$1.00; ph. \$1.00). *Modern Plastics* **23**, 161 (July 1946).
- [802.7] Polyvinyl carbazole in Germany. G. M. Kline. OTS PB 33272, 11 pages (1946) (mf. \$1.00; ph. \$1.00). *Modern Plastics* **24**, 157 (Oct. 1946).
- [802.8] German manufacture of polyvinyl ethers. G. M. Kline. *Chem. Ind.* **59**, 1018 (1946). *Modern Plastics* **24**, 159 (Jan. 1947).

### 803. Translation of Documents

- [803.1] Minutes of the I. G. Organic Chemicals Conference of 9-22-43 in Frankfurt. (Tr. by I. G. Callomon and G. M. Kline). OTS PB 1342, 78 pages (1945) (mf. \$1.00; ph. \$6.00). *Chem. Eng. News* **23**, 1841 (1945).
- [803.2] Polyvinylpyrrolidone. Fikentscher and Herrle (tr. by I. G. Callomon and G. M. Kline). OTS PB 1340, 33 pages (1945) (mf. 50¢; ph. \$1.00). *Modern Plastics* **23**, 157 (Nov. 1945).
- [803.3] A new synthesis of acrylic acid and its derivatives. W. Reppe (tr. by I. G. Callomon and G. M. Kline). OTS PB 1345, 12 pages (1945) (mf. 50¢; ph. \$1.00). *Modern Plastics* **23**, 162 (Nov. 1945).
- [803.4] Acetylene as a basis of a new industrial chemistry. W. Reppe (tr. by I. G. Callomon and G. M. Kline). OTS PB 2437, 31 pages (1945) (mf. 50¢; ph. \$3.00). *Modern Plastics* **23**, 169 (Feb. 1946).
- [803.5] High pressure polymerization of ethylene. Hopff and Goebel (tr. by I. G. Callomon and G. M. Kline). OTS PB 19486, 23 pages (1946) (mf. 50¢; ph. \$2.00). *Modern Plastics* **23**, 141 (May 1946).

- [S03.6] Emulsion polymerization of ethylene. Hopff and Kern (tr. by I. G. Callomon and G. M. Kline). OTS PB 19485, 47 pages (1946) (mf. 50¢; ph. \$1.00). *Modern Plastics* **23**, 153 (June 1946).
- [S03.7] Resins from phenol and acetylene. Hecht (tr. by I. G. Callomon and G. M. Kline). OTS PB 27774, 3 pages (1946) (mf. \$1.00; ph. \$1.00). *Modern Plastics* **23**, 152 (July 1946).
- [S03.8] Preparation of cross-linked polystyrenes. H. Hopff and E. Eckardt (tr. by I. G. Callomon and G. M. Kline). OTS PB 27775, 5 pages (1946) (mf. \$1.00; ph. \$1.00). *Modern Plastics* **23**, 155 (Aug. 1946).
- [S03.9] Manufacture of phenolic resins for molding and laminating in Germany. (Tr. of Production Manual of Dynamit A. G. by I. G. Callomon and G. M. Kline). OTS PB 30009, 13 pages (1946) (mf. \$1.00; ph. \$1.00). *Modern Plastics* **23**, 155 (Aug. 1946).
- [S03.10] Manufacture of phenolic molding compounds in Germany. (Tr. of Production Manual of Dynamit A. G. by I. G. Callomon and G. M. Kline). OTS PB 30008, 15 pages (1946) (mf. \$1.00; ph. \$1.00). *Modern Plastics* **24**, 160 (Sept. 1946).
- [S03.11] Manufacture of laminates in Germany. (Tr. of Production Manual of Dynamit A. G. by I. G. Callomon and G. M. Kline). OTS PB 32273, 20 pages (1946) (mf. \$1.00; ph. \$2.00). *Modern Plastics* **24**, 147 (Oct. 1946).
- [S03.12] Oxygen as activator and deactivator of polymerization. Heuck (tr. by I. G. Callomon and G. M. Kline). OTS PB 11404T, 35 pages (1946) (mf. \$1.00; ph. \$3.00). *Modern Plastics* **24**, 158 (Dec. 1946).
- [S03.13] Spray polymerization of vinyl ethers. Fickentscher, Gaeth, and Schwab (tr. by I. G. Callomon and G. M. Kline). *Modern Plastics* **24**, 162 (Feb. 1947).
- [S03.14] Condensation products of formaldehyde with amides and amines. H. Scheuermann (tr. by I. G. Callomon and G. M. Kline). *Modern Plastics* **24**, 161 (Feb. 1947).
- [S03.15] Polyurethanes. Otto Bayer (tr. by I. G. Callomon and G. M. Kline). *Modern Plastics* **24**, 149 (June 1947).

WASHINGTON, October 11, 1949.



